SmartConnect Use Case:

D5 - Power System Automatically Reconfigures for Reliability with the Help of the SmartConnect System

February 24, 2009

Document History

Revision History

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Approvals

This document requires following approvals.

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Contents

1. Use Case Description

1.1 Use Case Title

Power System Automatically Reconfigures for Reliability with the Help of the SmartConnect System.

1.2 Use Case Summary

The SmartConnect advanced metering system will extend the utility's sensing capabilities and communication infrastructure further down the distribution system while enabling a host of grid network optimization applications and services. This use case describes several scenarios in which the distribution network automatically reconfigures using a combination of distribution automation devices and SmartConnect system functions, either by making use of data provided by the SmartConnect meters or by providing better coordinated actions through the SmartConnect communications network itself. Moving intelligence out onto a grid enabled with SmartConnect communications, the utility can provide more predictive and targeted response actions to optimize performance and mitigate system abnormalities resulting in enhanced reliability and power quality for customers.

1.3 Use Case Detailed Narrative

This section provides a description of the use case in paragraph form.

1.3.1 Background and Context

SmartConnect has the potential to address many distribution network issues related to feeder loading and efficiency, voltage profiles, reliability, power quality, etc. by optimizing the coordination of switching devices and VAR resource controllers at a more localized level. Using the information that SmartConnect provides such as voltage and current measurements at customer sites, in addition to information provided by existing systems such as SCADA, the utility's ability to improve the quality and efficiency of network optimization applications and services increases significantly.

Today's distribution network operations are characterized by disparate, special purpose applications that are largely uncoordinated. The anticipated network optimization applications that stand to benefit from the SmartConnect system include:

- Loss Analysis
- Fault Location, Isolation and Service Restoration

- Contingency analysis
- Feeder reconfiguration
- Load shedding and load curtailment
- Protection re-coordination
- Voltage and VAR control
- Pre-arming of Remedial Action Schemes
- Intelligent alarm processing
- Transformer voltage regulation
- Load forecasting and state estimation
- Automatic feeder and capacitor bank switching
- Power quality monitoring and reporting
- Power quality contract compliance

Possible SmartConnect outputs that may serve these functions include:

- Real-time voltage
- Real-time current
- Power consumption by time interval
- Average voltage at customer site
- Voltage variations seen by the customer
- Harmonics (voltage and/or current)
- Power production by customer-supplied distributed generation
- Customer power factor

The business value from using SmartConnect data to perform automated system reconfiguration includes:

- Ramping off specific load rather than shutting down entire regions (substations, blocks, or cities) improves reliability and reduces the time required to completely restore power.
- Optimizing capacitor bank switching keeps customer voltage within band limits and permits more distributed generation – in turn, more distributed generation can provide grid benefits as elaborated in D3 Use Case.
- Remote monitoring of fault indicators reducing the need to dispatch field maintenance staff, and the time it takes to locate fault sources and resolve distribution grid issues

The applications can be separated into two categories – **online** and **offline**.

- The **online** category is considered a classification of real-time monitoring and control. Online applications include: intelligent alarm processing, coordinated volt/VAR control and fault location.

- The **offline** category involves evaluation of information gathered by the SmartConnect system from a historical perspective. Applications of this type generally retrieve data from a data historian that is periodically populated with new data from the SmartConnect system. Offline applications include: feeder optimization, load forecasting and power quality contract compliance.

In both online and offline categories applications using SmartConnect include two types of scenarios:

- Distribution automation devices or other types of utility equipment use the SmartConnect network to communicate.
- Network optimization applications use data captured by SmartConnect meters optionally augmented by information captured by the parallel distribution automation system.

1.3.2 Scenarios

This use case focuses on the **online** category of SmartConnect-aided distribution automation applications where real-time control applications are performed automatically by software or devices in the utility network with little or no human intervention.

There are four scenarios addressed in this use case:

1. **Meter disconnects or limits load based on voltage/frequency anomaly.** This scenario describes a distributed load shedding scheme enabled by the SmartConnect network. When a problem with voltage or frequency instability occurs in the power network, individual customer meters can choose to disconnect from the network using their integrated service switch rather than waiting for a distribution network operator to react.

   There are several benefits to this practice. Shedding the load automatically, allows the problem to be addressed more quickly than with human intervention, which can be critical in cases of instability where adverse operating conditions rapidly expand affecting large areas. Automatic disconnection by individual meters addresses the instability problem immediately in the area experiencing the earliest symptoms. Together, the additional speed and geographical focus of this technique prevents the voltage or frequency problem from propagating, which helps the utility sustain service for more customers. By disconnecting a limited number of customers early in the event, this type of targeted, distributed load shedding avoids the need to shut down entire regions (substations, blocks, or even cities).

   Frequency and voltage anomalies are treated as two separate sub-scenarios because of the different requirements associated with each and because the scenarios are not co-dependent from an implementation perspective. Significant voltage instabilities are generally more difficult to distinguish from momentary sags, swells and interruptions and require more frequent measurements.

   In each scenario, the precise selection of the threshold defining instability is critical. It is important that the algorithm not cause more reliability problems than it solves. In some cases it may be necessary to completely disable the function to avoid unnecessary disconnections.

2. **Capacitor Bank Controller (CBC) uses the AMI infrastructure to optimize customer voltage/power.** Existing capacitor control systems are triggered by the voltage at the local controller. These systems are typically set to activate based on an experienced best-

guess estimation of endpoint voltage derived from surveys and history. Sometimes this guess is based entirely on time of day, day of the week, or the season, but the reality is the level of response is highly dependent on the characteristics of the load and the distance of the load from the feeder origination. Feeder reconfiguration, variances of load source (e.g. time of day on a feeder that services a mixed residential and light industrial customer base) and other factors can make these preset response settings less than optimal.

This scenario describes a capacitor bank control mechanism consisting of two tiers: a Programmable Capacitor Controller (PCC) located at the remote site with the capacitor bank, and a Centralized Capacitor Controller (CCC). The CCC can be located in a high-level substation initially, but may potentially be an application running as a part of the future Distribution Management System (DMS) or other centralized Smart Grid control center system.

The two tiers have different responsibilities and capabilities. The PCC is responsible for controlling the bank based solely on its own voltage measurements made at one point on the feeder. The CCC, on the other hand, receives SmartConnect meter data on voltages measured at multiple points on the feeder, as well as overall VARs for the feeder measured by the SCADA system. Based on this information and a set of internal rules, it determines whether the voltage threshold settings for the PCC are appropriate. If not, it downloads new settings, permitting the PCC to switch the bank in and out more effectively. The benefits of this type of enhanced voltage control include:

- Improved circuit efficiency
- Loss reduction
- Energy savings
- More adaptable to distributed generation
- Can be integrated with a DMS

3. **DMS reconfigures feeder after a fault.** In this scenario, Remote Control Switches (RCS) and Remote Fault Indicators (RFI) report a fault through the SmartConnect communications network to the DMS. The DMS automatically (or perhaps with the approval of an operator) decides whether to open or close switching devices to restore power to the non-faulted portion of the affected feeder. As well as providing a communications network for the distribution automation devices, the SmartConnect system can also generate information about the expected load on each feeder segment to aid in determining whether to join the segments for restoration. This centralized data gathering and processing application with coordinated control capability requires the SmartConnect system be capable of determining which meters are located on what feeder segments. The details regarding this scenario are discussed in more detail in the asset utilization (D7) and outage management (D4) use cases.

4. **Remote circuit switches autonomously reconfigure after a fault.** This scenario is similar to the previous one in that RCS and RFI automatically restore power to a non-faulted circuit segment after a fault. However, it describes how they may perform this task without the aid of the DMS, through peer-to-peer communications. This type of solution, using distributed intelligence, may produce quicker resolution and recovery times than a centralized scheme because the decision-making process takes place closer to the source of the problem. The SmartConnect network must provide a higher level of service (greater bandwidth/lower latency) to achieve this level of functionality , and that may not be possible at this time.

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Scenarios 3 and 4 require communication with distribution automation devices when portions of the power network are de-energized. Without ongoing communications throughout the fault, the complexities of sorting out recloser, sectionalizer, and fuse timings become considerably more difficult to coordinate. By maintaining communications between energized and non-energized elements, the system has several options for reconfiguring the affected portions of the distribution network reducing the number of individual customer outages and the labor required to restore service.

These scenarios assume there will continue to be parallel distribution automation (SCADA) and SmartConnect networks to reach different devices. When it comes to future expansion, retrofitting existing distribution automation devices would prove costly, while avoiding parallel operation of communications infrastructures is more cost effective if one network can provide both functions.

Low cost RFI would facilitate deployment of more RFI. This would reduce restoration time improving reliability statistics. Reduction in cost can also be realized by rapidly dispatching people to the appropriate location.

1.4 Business Rules and Assumptions

- The Advanced Distribution Automation and network optimization functions are viewed as *black boxes* by the industry. This use case focuses on what information should be provided on the functions it addresses, and the information received by them, not their algorithms.
- The SmartConnect system will not replace the SCADA/DMS system; it will merely enhance existing systems.
- Using information from the SmartConnect system improves existing power system applications and facilitates the creation of new ones.
- The Transformer Load Management (TLM) Database has sufficiently accurate topology information showing which meters are connected to what feeders for the CCC application to determine a mapping between PCC and meter voltage histories.
- Existing Remote Fault Indicator (RFI) devices are capable of replacing those the utility presently uses for communicating over the SmartConnect network.

2. Actors

Describe the primary and secondary actors involved in the use case. This might include all the people (their jobs), systems, databases, organizations, and devices involved in or affected by the function (e.g. operators, system administrators, customers, end users, service personnel, executives, meters, real-time database, ISO, power systems). Actors listed for this use case should be copied from the global actors list to ensure consistency across all use cases.

Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Centralized Capacitor Control (CCC)	Software Application	Envisioned as part of the DMS that adjusts the settings on remotely located PCCs so they optimally switch their assigned capacitor banks to reduce energy loss. Gathers voltage and VAR information from the SmartConnect and SCADA systems to accurately determine appropriate voltage thresholds.
Distribution Management System (DMS)	System	Integrates the functions of SCADA, outage management, work management, distribution load management, reactive control, and asset management into a single console and set of applications. It will replace the existing DCMS.
Geographic Information System(GIS)	System	Maintains information about the power grid. Maintains location information about grid assets as well as their capabilities and relationships between assets. For example, the system can maintain capacitor banks associated with a particular meter given a particular feeder configuration.
Programmable Capacitor Controller (PCC)	Device	Located in a substation or near a capacitor bank. Switches the capacitor bank in or out of the power network based on preconfigured voltage thresholds. Is a component in the SCADA and/or SmartConnect communications network and reports its voltage and switch position to the DMS.
Re-closer	Device	A programmable circuit breaker designed to clear transient faults by opening on over-current and while making one or more attempts to close it, the delay time gets progressively longer. These programmed delays are a balance between minimizing outages and providing adequate time for the fault path to reacquire adequate dialectic strength, thus the progressive nature.
Remote Circuit Switch (RCS)	Device	A distribution switch that is operable from a remote location
Remote Fault Indicator (RFI)	Device	Determines whether fault current has passed it and sends notice of this fault current passage to a central system.

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Actor Name	Actor Type (person, device, system etc.)	Actor Description
SmartConnect Meter	Device	Advanced electric revenue meter capable of two-way communications with the utility. Serves as a gateway between the utility, customer site and customer's load controllers. The meter measures, records, displays, and transmits data such as energy usage, generation, text messages, event logs, etc. to authorized systems (i.e., the SmartConnect NMS) and provides other advanced utility functions.
SmartConnect Network Management System (NMS)	System	The utility back-office system responsible for remote two-way communications with the SmartConnect meters to retrieve data and execute commands. The SmartConnect NMS is responsible for balancing load on the communications network resulting from scheduled meter reads and retrying meters when communications fail.
Transformer Load Management (TLM) Database	System	Stores two main types of information: connectivity data describing which customers are connected to which transformers, switches, segments, circuit breakers, feeders or other elements of the distribution system; and historical loading data, capturing how much any of these elements is loaded at a given time. The TLM database also includes software applications that generate analyses and reports from this data periodically or on-request.

3. Step by Step analysis of each Scenario

3.1 Primary Scenario: Meter disconnects or limits load based on voltage/frequency anomaly

This scenario describes how a SmartConnect Meter can choose to disconnect from the power network using its integrated service disconnect switch when it detects a frequency or voltage instability problem. Such action, taken by many meters, can serve as a limited, geographically localized, distributed load shedding scheme to help address the anomaly. There are two slightly different scenarios, one for a frequency anomaly and the other for a voltage anomaly. It should be noted that significant voltage instabilities are generally more difficult to distinguish from momentary sags, swells and interruptions and require more frequent measurements than frequency instabilities.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
(Identify the name of the event that initiates the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to complete the scenario)*
Meter detects frequency or voltage anomaly by comparing frequency against configured parameters.	SmartConnect Meter	Meter is operating normally.	Meter reconnects as frequency or voltage recovers within normal range.

3.1.1 Steps for Scenario A: Frequency Anomaly

Describe the normal sequence of events required to complete the scenario.

Step #	***Actor***	***Description of the Step***	***Additional Notes***
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or step value to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	SmartConnect Meter	Monitors frequency at the meter terminal.	
2	SmartConnect Meter	Detects an under-frequency anomaly.	The use of distributed generation to respond to under-frequency situations will be considered in a separate use case (D3).
3	SmartConnect Meter	Verifies frequency against threshold.	Under-frequency or rate-of-change (ROC) value set points.
4	SmartConnect Meter	Operates disconnect at random intervals after thresholds are reached.	It is possible to disable the disconnect action through remote configuration.
5	SmartConnect Meter	Reconnects a random time after frequency recovers within normal range.	As frequency recovers, the meter reconnects after a settable stabilizing time and then energizes in random order; that is, if meter was not disconnected for another reason, such as non-payment.
6	SmartConnect Meter	Logs frequency anomaly, disconnect and reconnect events for later retrieval as part of daily meter read.	

3.1.2 Steps for Scenario B: Voltage Anomaly

Describe the normal sequence of events required to complete the scenario.

Step #	Actor	Description of the Step	Additional Notes
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or step value to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	SmartConnect Meter	Monitors voltage.	
2	SmartConnect Meter	Detects a voltage that is out of range (too high/too low) for a configured (long) period of time.	
3	SmartConnect Meter	Disconnects after an adjusted time delay.	
4	SmartConnect Meter	Restores voltage to normal value.	
5	SmartConnect Meter	Re-connects service.	After a random delay.
6	SmartConnect Meter	Logs voltage threshold exceeded, disconnect and reconnect events for later retrieval as part of daily meter read.	Alternately may be configured to report them at the time of occurrence.

3.2 Primary Scenario: Capacitor bank controller uses the AMI infrastructure to optimize customer voltage/power

This scenario describes a two-tiered system for capacitor bank control in which the CCC optimizes the settings for remote PCCs based on voltage and VAR readings gathered from multiple points on the feeder via the SmartConnect system.

Triggering Event	Primary Actor	Pre-Condition	Post-Condition
(Identify the name of the event that initiates the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to complete the scenario)*
Voltage on the distribution feeder varies as the day progresses and requires adjustment of PCC settings.	DMS	A subset of meters is configured to report voltage and VAR information to the DMS. Voltage is initially within acceptable limits.	Voltage on distribution feeder remains within acceptable limits.

3.2.1 Steps for this scenario

Describe the normal sequence of events required to complete the scenario.

Step #	Actor	Description of the Step	Additional Notes
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or step value to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	SmartConnect Meter	Monitors voltage.	
2	SmartConnect Meter	Stores the monitored information.	Records voltage, on average once every 15 minutes.
3	SmartConnect Meter	Provides monitored voltage history back to SmartConnect NMS as a part of the normal read cycle.	
4	SmartConnect NMS	Separates voltage information from usage and sends it to CCC.	
5	CCC	Determines which PCCs are associated with the incoming voltage and VAR data.	CCC may be implemented as part of a larger DMS

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Step #	Actor	Description of the Step	Additional Notes
6	CCC	Evaluates the PCC settings based on: • CPUC Rule #2. • Actual PCC voltage measured through SCADA and/or SmartConnect communications network. • Alarm and status messages received directly from the PCC (possibly via the SmartConnect network). • Meter voltage history from multiple meters via SmartConnect network. • Messages/events from meters near or associated to a given PCC, via the SmartConnect network, indicating voltages beyond the set thresholds. • VARs on feeder measured through SCADA and/or SmartConnect network.	Alarm and status messages from the PCC may include: • Out of preset bands • Physical problem with the bank • Voltage threshold exceeded • Open/closed status
7	CCC	Adjusts the PCC settings if required.	May be through SCADA or SmartConnect networks.
8	PCC	Confirms the changes to the PCC settings.	
9	CCC	Validates the setting changes.	Steps 1-8 will repeat until desired settings are attained.

3.3 Primary Scenario: Distribution Management System (DMS) reconfigures feeder after a fault.

Using a combination of Remote Fault Indicators (RFI) and Remote Control Switches (RCS) this scenario describes recovery from a fault on one of the two feeders pictured in Figure 1 on page 21. The decision to close the normally open switch between the two feeders in order to restore power to a portion of the faulted feeder is made by a centralized application running on the DMS. The system can provide decision-support to a human operator who uses the information to make informed control actions.

The main contribution of the SmartConnect system in this scenario is communication between the devices and the DMS made through the SmartConnect communications network. The messages exchanged do not require a particularly high-bandwidth or low-latency network; in fact, human intervention may be part of the communications loop, approving or rejecting the recommendation of the DCMS application resulting in the further slowing of the message exchanges.

A second contribution of the SmartConnect system is it lets the DMS decide whether to link the feeders based on loading information on the two feeders. This loading information and the topology information supporting it could be obtained from the SmartConnect system as described in other use cases (D7).

Triggering Event	***Primary Actor***	***Pre-Condition***	***Post-Condition***
(Identify the name of the event that initiates the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to complete the scenario)*
Fault occurs on a feeder between RFI-1 and RFI-2 requiring feeder switching to restore power to most customers.	DMS	No faults detected.	Power restored to all non-faulted circuit sections.

3.3.1 Steps for this scenario

Describe the normal sequence of events required to complete the scenario.

Step #	Actor	Description of the Step	Additional Notes
1	RFI	DMS receives notice from RFI-1, reporting a fault.	SmartConnect communications network may be used to enable communications between DMS and distributed devices such as RFI and RCS making an extension/expansion to existing Distribution Automation technology possible.
2	Recloser-2	Opens and reports status to DMS.	
3	DMS	Receives notice from RCS-2 reporting loss of voltage.	
4	Recloser-2	Closes after 15 seconds and reopens.	
5	DMS	Once again receives notice from RFI-1 reporting a fault.	
6	RCS-2	Opens after 30 seconds and reports status to DMS.	
7	Recloser-2	Closes after 40 seconds (55 seconds after fault), reopens, and locks out, sending report status to DMS.	
8	DMS	Determines RCS-3 (direct operate) must close based on: • Historical loading (pre-fault conditions) • Expected load after restoration	Note that loading information in the past may have been available at a greater level of granularity than today, due to requirements that load data be available for transformer points or circuit segments. (Use Cases D7 and D8).

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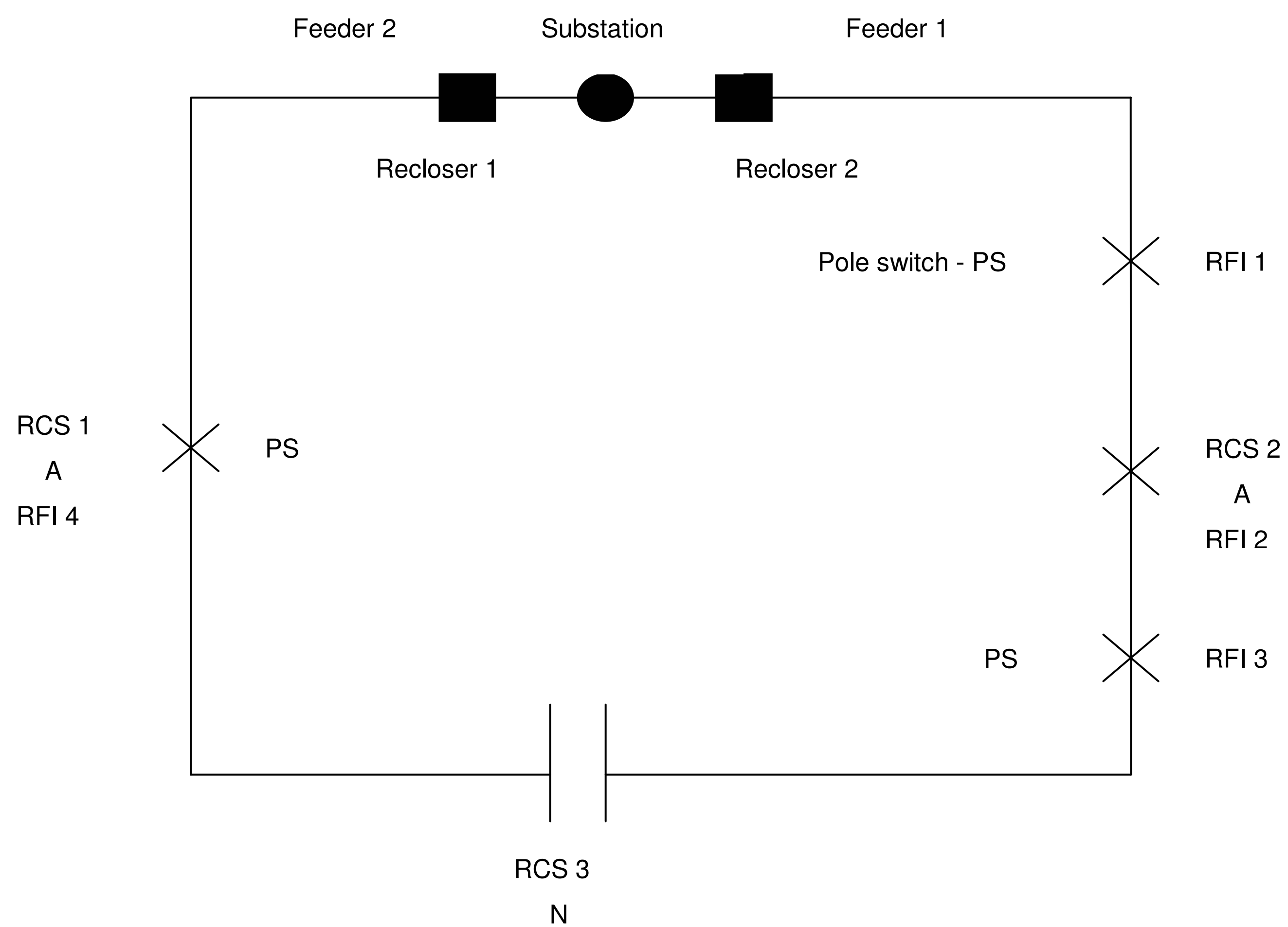

Figure 1 – Distribution Automation Example – Fault Between RFI-1 and RFI-2

3.4 Alternate Scenario: Remote Circuit Switches autonomously reconfigure after a fault.

This scenario describes recovery from a fault on one of the two feeders pictured in Figure 1 on page 21, using a combination of Remote Fault Indicators (RFI) and Remote Control Switches (RCS), but there is no communication with the DMS. Instead, the decision to link the two feeders is made by one of the RCS based on information provided by the other RCS and RFI.

The collaborative nature of the scenario makes it difficult to document the steps with any definitive precedence of operations or assignment of responsibilities. This particular sequence only represents one of many possible solutions. For example, this scenario assumes the recloser continues to operate in an awkward fashion with no coordination with other system elements and each RCS responds to requests from other devices, but only initiates action based on self-interest (maintaining its desired state of energized, fault-free on both sides).

The primary participation of the SmartConnect system in this scenario is to provide a communications network to be used by the distribution automation devices. Because this scenario requires shorter latencies and peer-to-peer communications between the devices, it may not be possible with existing SmartConnect technology.

Triggering Event	***Primary Actor***	***Pre-Condition***	***Post-Condition***
(Identify the name of the event that initiates the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to complete the scenario)*
A fault occurs on a feeder between RFI-1 and RFI-2, requiring feeder switching to restore power to most customers.	Recloser	No fault detected. RCS, RFI devices require coincident grid topology and associated devices. RCS devices are programmed to insure fault-free voltage on both sides. Scenario does not assume new intelligence or communication capabilities in the recloser.	Feeder reconfiguration is complete.

3.4.1 Steps for this scenario

Describe the normal sequence of events required to complete the scenario.

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Step #	*Actor*	*Description of the Step*	*Additional Notes*
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or step values to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1		Fault on Feeder between RFI-1 and RFI-2.	Triggering event.
2	RFI-1	Reports fault to RCS-1, RCS-2 and RCS-3.	
3	Recloser-2	Opens.	
4	RCS-2	Reports loss of voltage to RCS-1 and RCS-3.	
5	Recloser-2	First reclose occurs after 15 seconds and reopens	
6	RFI-1	Again reports a fault to RCS-1, RCS-2 and RCS-3.	
7	RCS-2	Opens after 30 seconds and reports status to DMS and other peer equipment as necessary.	
8	Recloser-2	Closes after 40 seconds (55 seconds after fault), reopens and then locks out.	
9	RCS-3	Senses loss of voltage on RCS-2 segment side, requesting status of RFI-3.	
10	RFI-3	Responds with no voltage/no fault.	
11	RCS-3	Closes and broadcasts status to DMS and other peer equipment as necessary.	
12	RFI-3	Announces voltage/no fault to RCS-1, RCS-2, and RCS-3.	
13	RCS-3	Reports configuration to DMS.	

4. Requirements

Detail the functional, non-functional and business requirements generated from the workshop in the tables below. List the associated use case scenario and step if applicable.

4.1 Functional Requirements

Functional Requirements	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
Each meter shall be capable of measuring, recording and reporting power frequency.	1A	1
Each meter shall be capable of logging events for voltage out of tolerance (compared to set threshold) for later reporting back to the utility.	1A, 1B	6
Each meter shall be able to calculate, record and report the ROC of power frequency with time (df/dt).	1A	3
Each meter shall permit remote configuration and storage of at least one under-frequency threshold.	1A	4
Each meter shall permit remote configuration and storage of at least one frequency ROC threshold.	1A	4
Each meter shall open its integrated disconnect switch whenever its under-frequency threshold is exceeded.	1A	4
Each meter shall open its integrated disconnect switch whenever its frequency ROC threshold is exceeded.	1A	4
Each meter shall close its integrated disconnect switch upon return to frequency and frequency ROC thresholds that are within the set normal range.	1A	4
The DMS and SmartConnect NMS shall coordinate under-frequency threshold settings on meters with the frequency settings in substations so that the meter disconnects before the substation protection trips out any higher level equipment.	1A	4
Each meter shall be delayed a random amount of time before disconnecting or reconnecting service due to either frequency or voltage thresholds.	1A 1B	4,5 3,5

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Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Each meter shall discriminate between voltage or frequency anomaly disconnects vs. other disconnects (e.g. non-payment). The meter shall not reconnect service after an anomaly if there are other reasons for service disconnection.	1A 1B	5 5
Each meter shall be able to disable its capability to automatically operate its integrated disconnect switch in response to frequency and voltage anomalies (per remote configuration instructions).	1A 1B	4,5 3,5
Each meter shall log the reason for each operation of its service switch.	1A	5
Each meter shall be capable of monitoring, recording and reporting RMS voltage (240 V).	1B 2	1 1
Each meter shall permit remote configuration and storage of high-voltage and low-voltage disconnect thresholds and corresponding qualification intervals.	1B	2
Each meter shall open its integrated disconnect switch if its configured high-voltage or low-voltage disconnect thresholds are exceeded for the configured qualification interval.	1B	3
Each meter shall not disconnect service if voltage is absent on the utility side.	1A, 1B	5
Each meter shall report frequency and voltage disconnect/reconnect events at the time of occurrence if configured to do so.	1A, 1B	6
Each meter shall permit the remote configuration and storage of high-voltage and low-voltage quality thresholds, independent of the voltage thresholds for disconnecting service.	2	1
Each meter shall be remotely configurable to periodically record average voltage and report this information, time-stamped, as part of the normal meter read.	2	2, 3
Each meter shall be remotely configurable to record the daily high-voltage and low-voltage and report this information, time-stamped, as part of the normal meter read.	2	2, 3
Each meter shall generate an event if either the high-voltage or low-voltage quality threshold is exceeded and report that event as it occurs and as part of the normal meter read.	2	2
The SmartConnect NMS shall separate average voltage history and high-voltage and low-voltage quality information from normal meter reads and forward it to the CCC application (likely in the DMS).	2	4

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Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
The CCC application in the DMS shall be able to determine which meter voltage histories gathered by the SmartConnect system are associated with particular PCCs in substations or on pole-tops. The source of this information can be: • Manual configuration within the CCC • The TLM Database • The GIS or OMS system connectivity database	2	5

The CCC application in the DMS shall remotely adjust PCC settings based on:
• CPUC Rule #2
• Information measured through SCADA and/or SmartConnect network
  ○ Actual PCC voltage
  ○ Capacitor bank status and alarms (e.g. open/closed, out of preset bands, threshold exceeded, physical failure)
  ○ VARs on feeder
• Information measured through SmartConnect network from multiple meters near or associated with the PCC
  ○ Meter voltage history
  ○ Meter events indicating voltages beyond thresholds
	2	6,7,8

PCC co-located with capacitor banks shall switch their capacitor banks based on voltage measured by the PCC and voltage thresholds received from the CCC at the DMS.	2	7
The SmartConnect communications network shall be able to transport status, event, and command messages between PCCs, meters, and the CCC.	2	6,7,8
PCCs shall be able to acknowledge receipt of commands and confirmation of settings changes back to the CCC.	2	8
The SmartConnect communications network and SmartConnect NMS shall permit distribution automation devices such as RFI and RCS to report events such as faults, loss of voltage, and switch status to the DMS as they occur.	3	2,3,5,6

D5 - Power system automatically reconfigures for reliability with the help of the SmartConnect system

Functional Requirements	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
Each RFI shall report the following information to the DMS when a fault occurs: • ID • Time • Fault indication • Fault magnitude	3	2,5
Communications from distribution automation devices (e.g. RCS and RFI to the distribution control and monitoring system shall be available when the power is out.	3	2,3,5,6
Each RCS shall report to the DMS the following information when the switch status changes: • ID • Time • All of its status points including status of A/C (alternating current) power on both sides of the switch	3 4	3,6, 8 13
Each RCS shall be able to receive control from the DMS and send acknowledgment.	3	8
The DMS shall be able to retrieve load history for any feeder segment from the TLM Database per Use Case D7.	3	8
RCS and RFI devices shall be able to communicate with each other over a peer-to-peer type communications network.	4	2,4,6,7,9,10,11,12
The SmartConnect communications network shall permit RCS and RFI devices to communicate over a peer-to-peer network, without the need to pass thru a central communications server.	4	2,4,6,7,9,10,11,12

4.2 Non-functional Requirements

D5 - Power system automatically reconfigures for reliability with the help of the SmartConnect system

Non-Functional Requirements	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
Each meter shall be able to measure power frequency with accuracy “X” (See action item to determine “X”: reference ANSI standards).	1A	1
Each meter shall ensure that configured low-frequency disconnect thresholds are higher than 59.5 Hz, which is the frequency at which substations perform under-frequency load shedding.	1A	
Each meter shall consider utility-side voltage to be absent if it is below 12V (for 120V nominal) or 24V (for 240V nominal). NOTE: These values have not been finalized.	1A	4
Each meter shall have a default high-voltage disconnect threshold of 140V (for 120V nominal) or 280V (for 240V nominal). NOTE: These values have not been finalized.	1B	2
Each meter shall have a default low-voltage disconnect threshold of 100V (for 120V nominal) or 200V (for 240V nominal) NOTE: These values have not been finalized.	1B	2
Each meter shall have a default voltage average interval of 15 minutes.	2	1
Each meter shall have a default low-voltage quality event threshold of 110V (for 120V nominal) or 220V (for 240V nominal). NOTE: These values have not been finalized.	2	2
Each meter shall have a default high-voltage quality event threshold of 130V (for 120V nominal) and 260V (for 240V nominal). NOTE: These values have not been finalized.	2	2
The SmartConnect communications network shall permit PCCs to transmit voltage, status and events to the CCC in less than 60 seconds.	2	6
Security of the SmartConnect communications network in reporting faults and operating switches shall be at a level consistent with a SCADA control (switch operation).	3 4	1,5,8
Fault report from an RFI shall be at DMS in less than 5 seconds (time of fault to annunciation)	3	1,5
Communication to DMS from distribution automation devices shall be available for at least 8 hours with power out.	3	1,5
Number of devices communicating for the purpose of carrying out Scenario #4 is 6-8 per circuit.	4	1
The SmartConnect communications network shall permit up to 12 circuits to exercise Scenario #4 simultaneously.	4	1

4.3 Business Requirements

Business Requirements	Associated Scenario # (if applicable)	Associated Step # (if applicable)

5. Use Case Models (optional)

5.1 Information Exchange

Scenario #	*Step #*	*Information Producer*	*Information Receiver*	*Name of information exchanged*
1A	3	SmartConnect NMS	SmartConnect Meter	Frequency Threshold Disconnect Delay Time
1A	4	SmartConnect Meter	Disconnect Switch	Disconnect Command
1A	5	SmartConnect Meter	Disconnect Switch	Reconnect Command
1A	6	SmartConnect Meter	SmartConnect NMS	Frequency Anomaly Event, Disconnect Event Reconnect Event Usage History
1B	2	SmartConnect NMS	SmartConnect Meter	Voltage Threshold Disconnect Delay Time
1B	3	SmartConnect Meter	Disconnect Switch	Disconnect Command
1B	5	SmartConnect Meter	Disconnect Switch	Reconnect Command
1B	6	SmartConnect Meter	SmartConnect NMS	Voltage Anomaly Event Disconnect Event Reconnect Event Usage History
2	3	SmartConnect Meter	SmartConnect NMS	Voltage History Usage History
2	4	SmartConnect NMS	CCC	Voltage History

D5 - Power system automatically reconfigures for reliability with the help of the SmartConnect system

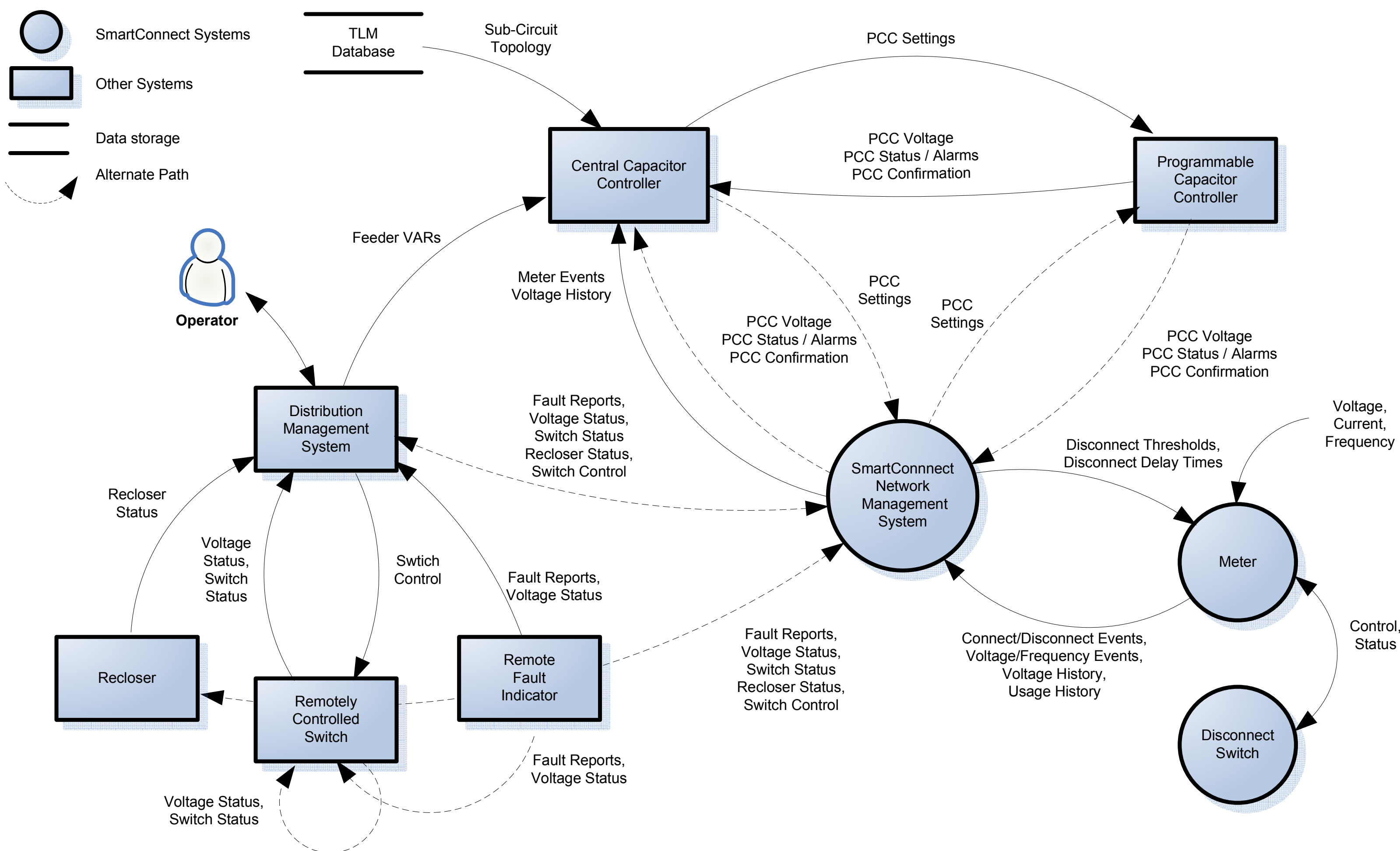
Scenario #	Step #	Information Producer	Information Receiver	Name of information exchanged
2	6	PCC	CCC	PCC Voltage PCC Alarms/Status
2	6	SmartConnect NMS	CCC	Voltage History Meter Events
2	6	DMS	CCC	Feeder VARs
2	7	CCC	PCC	PCC Settings
2	8	PCC	CCC	PCC Confirmation
3	1	RFI-1	DMS	Fault Report
3	2	Recloser-2	DMS	Recloser Status (open)
3	3	RCS-2	DMS	Voltage Status (no voltage)
3	4	Recloser-2	DMS	Recloser Status (closed) Recloser Status (open)
3	5	RFI-1	DMS	Fault Report
3	6	RCS-2	DMS	Switch Status (open)
3	7	Recloser-2	DMS	Recloser Status (closed) Recloser Status (open) Recloser Status (lockout)
3	8	DMS	RCS-3	Switch Control (closed)
4	2	RFI-1	RCS-1, RCS-2, RCS-3	Fault Report
4	4	RCS-2	DMS, RCS-1, RCS-3	Voltage Status (no voltage)
4	5	Recloser-2	DMS	Recloser Status (closed) Recloser Status (open)
4	6	RFI-1	RCS-1, RCS-2, RCS-3	Fault Report

D5 - Power system automatically reconfigures for reliability with the help of the SmartConnect system

Scenario #	Step #	Information Producer	Information Receiver	Name of information exchanged
4	7	RCS-2	DMS, RCS-1, RCS-3	Switch Status (open)
4	8	Recloser-2	DMS	Recloser Status (closed) Recloser Status (open) Recloser Status (lockout)
4	9	RCS-3	RFI-3	Status Request
4	10	RFI-3	RCS-3	Voltage Status (no voltage) Fault Report (no fault)
4	11	RCS-3	DMS, RCS-1, RCS-2	Switch Status (closed)
4	12	RFI-3	DMS, RCS-1, RCS-2, RCS-3	Voltage Status (voltage OK) Fault Report (no fault)

5.2 Diagrams

5.2.1 Data Flow Diagram



6. Use Case Issues

Capture any issues with the use case. Specifically, issues that are not resolved and help the use case reader understand the constraints or unresolved factors that have an impact of the use case scenarios and their realization.

Issue
Determine/verify resolution of meter measurement for under-frequency detection (reference ANSI standards).
Investigate Rule #2 of CPUC. Include in this use case a summary of the rule and the required time frame to meet the 120 V +0 -5%
Research how implementing Scenario #2 will affect the amount of capacitor bank switching performed. Is it likely to increase or decrease the number of switching operations, or will it have no effect?
Perform power system analysis to determine the effect of under-frequency disconnect responses by meters on the speed of resolution of under-frequency events.
Consider appropriate set points for frequency, voltage, and related rate-of-change thresholds. Take care that these do not result in undesired operation of remote disconnect switch leaving customers without power.
In Scenario #4, further exploration is required to understand specifically what information is required by the distribution automation devices in order to make effective switching decisions? Do they need to know topology information? Loading information? Connectivity, e.g. 2-wire vs. 3-wire?
Explore preferred communications network to be used by the CCC on the DMS used to change voltage threshold settings on the PCC.
Explore preferred communications network to be used by DMS to open and close RCSs.

7. Glossary

Insert the terms and definitions relevant to this use case. Please ensure that any glossary item added to this list is included in the global glossary to ensure consistency between use cases.

Glossary	
Term	**Definition**
ROC	Rate-of-change.
SCADA	Supervisory Control and Data Acquisition – the existing distribution automation communications network.

8. References

Intelligrid Use Cases D 11.2

OpenAMI Use Case #6

9. Bibliography (optional)

Provide a list of related reading, standards, etc. that the use case reader may find helpful.